Strategy Research Project

A COMPARISON OF U.S. RESPONSES TO UNEXPECTED TECHNOLOGY BREAKTHROUGHS

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A COMPARISON OF U.S. RESPONSES TO UNEXPECTED TECHNOLOGY BREAKTHROUGHS

America is in a persistent conflict that will test America's will to fight. The enemy, lacking superiority in technology, will use technology he has available in new, insidious, and unexpected ways to achieve his objectives. This is the essence of asymmetric warfare. Yet today, after seven years of conflict, the United States is only now beginning to assess how well it is prepared to counter new, unexpected, or asymmetric uses of technology.[1]

The United States has a history dating back to the American Civil War of responding to perceived technology weaknesses, gaps or unexpected technology breakthroughs. This history has left a bewildering array of organizations and processes. U.S. responses to technology gaps and a desire to use science and technology better within the government have resulted in the creation of two types of organizations: advisory and operational. Advisory organizations such as the National Academy of Sciences (NAS) created during the Civil War by President Lincoln or the National Research Council (NRC) created by President Wilson during World War I, were usually reactionary in nature and dependant on a US governmental department tasking them to research a scientific area. Operational organizations such as the National Defense Research Committee (NDRC), the Defense Advanced Research Projects Agency (DARPA) and the Joint Improvised Explosive Device Defeat Organization (JIEDDO) have proven to be more effective in developing responses to unexpected technology breakthroughs or technology gaps.

The number of organizations and processes has created development challenges and inefficiencies contributing to technology gaps. Technology development efforts are often executed in an uncoordinated, duplicative manner that does not produce the best results.[2] Most recently with the case of Improvised Explosive Devices (IEDs) in Iraq and Afghanistan, while the United States had imaginative technologies available, it did not have an effective method to predict new adversarial technology uses and lacked a process to rapidly react to these challenges. This asymmetric surprise threatened United States resolve by increasing U.S. casualties and helping to turn popular support away from the war in Iraq and jeopardizing our national interest. Thus a lack of capability to respond to an emerging unexpected technology directly threatened a vital U.S. interest.

This essay examines three historical examples of how the United States responded to unexpected technology developments and gaps, and offers a set of recommendations to improve the United States' ability to respond to technology innovations or breakthroughs.

Case I: The National Defense Research Committee (NDRC)

The United States has a history of technological prowess dating back to the industrial revolution. The term "Yankee ingenuity" and the long list of American inventors and inventions are testaments of the abilities of American industry to develop technology for commercial purposes. Even today the United States creates more patents for new items then all other countries in the world combined.[3] This technology development fueled the United States' economic expansion and industrialization. However, prior to World War II, U.S. military technology and weapons development

lagged behind commercial technology development. So while America developed car radios and commercial aircraft, Germany developed radios for tanks that facilitated blitzkrieg tactics and Japan developed the best naval fighters, bombers and aircraft carriers.[4] The result was that in the spring of 1940, when Nazi Germany invaded France, America was deemed “pathetically unprepared” [5] to fight a war from the standpoint of new weapons. The individuals making this assessment of the United States technology gap were not from the military profession, but rather the elite of American industry and academia. Four men in particular took the initiative to call on President Roosevelt to address the weapons technology gap. Vannevar Bush, President of the Carnegie Institution of Washington (Now called the Carnegie Institute for Science), Karl Taylor Compton, President of Massachusetts Institute of Technology (MIT), James Bryant Conant, President of Harvard University, and Frank Baldwin Jewett, President of the National Academy of Sciences and Bell Telephone Labs.

As these men saw it, one of the fundamental problems with weapons development was the central theory that the military services would know what technology was needed and then ask scientists and engineers to aid in developing the technology into a weapon system.[6] However, due to the small size of the armed services and the all-out effort to needed to reorganize and prepare for war, the team felt that science had progressed to a point where industry and academia could better serve in identifying what technology could do to meet enhance military effectiveness. They recommended reversing the process.[7] In essence it was a “technology push” rather than traditional requirements based pull on technology development. The team persuaded

President Roosevelt, Army Chief of Staff - General Marshall, and Chief of Naval Operations - Admiral Stark to create a committee with broad powers to:

> aid and supplement the experimental and research activities of the War and Navy Departments…conduct research for the creation and improvement of instrumentation, methods and materials of warfare, and to utilize the laboratories and equipment of the National Bureau of Standards, and other Governmental institutions."[8]

On 27 June 1940, the National Defense Research Committee was created with the approval of the President. The team of four would now lead the committee and take the lead in reducing America's military technology gap. The committee leadership team was expanded to eight members to include senior representatives from the Army and Navy along with the Commissioner of Patents and a senior professor from the California Institute of Technology (CALTECH). These members all served "pro bono" one to two days per week while maintaining their status within their parent organizations. As the committee organized and expanded into divisions to cover needed technology areas new members were also expected to work under those same conditions.[9]

One of the critical first steps for the committee was to ascertain what developmental projects the military departments were working on and what technologies were being worked within industry and academia along with research capabilities of all laboratories and research facilities.[10] Leveraging their personal ties with the services, academia, and industry, the committee rapidly developed and maintained an extensive list of ongoing research and capabilities.

Another important power the committee had was that it did not require approval from the services to conduct research and to develop weapon systems. While the committee worked hard to ensure a well-coordinated effort in assisting the services, their development was often conducted over the resistance of the services.[11]

In the process of spurring on weapons development, the committee continued to expand. The committee soon had five divisions working armor and ordnance, bombs, fuels, gases and chemical problems, communications and transportation, patents, and a strange new technology called atomics and uranium. From a first budget of $6.5 million the committee and its follow-on organization, the Office of Scientific Research and Development (ORSD) would grow to have a total war time expenditure of $500 million.[12] Imbued with the sense of urgency due to the looming war, the committee worked to overcome the lack of personnel, contracting issues, handling suggestions from the public, and evaluating and prioritizing what projects needed to be worked. They also quickly established better liaison with the Army and Navy as well as the United Kingdom.[13]

Eventually it became obvious that while the NDRC was making progress in initiating scientific research to solve military problems, a gap existed between research and fielding the new equipment. Additionally, as research expanded, better coordination was needed to ensure services, industry, and academia was leveraging all available knowledge gained. Finally, while much work had started on military weapons, the success the NDRC was having suggested to President Roosevelt that similar gains could be made in the area of military medicine.[14] On June 28, 1941, President Roosevelt signed an executive order reorganizing the NDRC and establishing the Office of Scientific Research and Development (OSRD) providing the office with broad powers to:

> Advise the President with regard to the status of scientific and medical research relating to national defense.
>
> Serve as the center for mobilization of the scientific personnel and resources of the national…applying such resources to defense purposes.

> Co-ordinate, aid, and where desirable supplement experimental and other scientific and medical research activities relating to national defense carried on by the Departments of War and Navy and other departments and agencies of the Federal Government.
>
> Develop broad and co-ordinate plans for scientific research in defense programs.
>
> Initiate and support scientific research on mechanisms and devises of warfare to create and improve instruments, methods and materials required for national defense.
>
> Initiate and support scientific research on medical problems.
>
> Initiate and support scientific and medical research as requested by the government of any country the President deems necessary to the vital to defense of the United States.[15]

The work of the OSRD continued to expand and much of its activities centered on creating liaison offices and field offices that collected information and spurred on collaboration with services, foreign governments, and field services. By the war's end NDRC/OSRD had made major contributions in weapons development and production. They were the catalysts for rapidly developing emerging technologies such as radar and radar-based fire control, the Variable Time Fuze (VT fuze), the DUKW amphibious truck, and the atomic bomb. In each case the NDRC or OSRD championed the technology and obtained the resources to develop to technology into a deployable system. The NDRC and OSRD worked to resolve production technology issues as well. Most significantly, with Japan controlling about 90% of the world supply of natural rubber, the NDRC/OSRD developed synthetic rubber for military vehicles.[16] Within five years these efforts had closed the technology gap and transformed the United States military into the world technological leader. The U.S. had responded to unexpected Axis technology breakthroughs with a series of breakthroughs of its own. For example, countering Germany advances in tank design, the U.S. combined technical advances

like the VT fuze and communications advances with changes in tactics including fire direction centers and forward observers to put the U.S. Field Artillery a full generation ahead of any other military in artillery.[17] In the end, it was the United States that developed the atomic bomb and achieved surprise on Japan (who though that the United States was actually behind their own program to develop the weapon). Another way of responding to an unexpected technology breakthrough was to counter it by adapting tactics, techniques, and procedures (TTPs) with new technologies in a combined response to compensate for and then to overwhelm the enemy. An example of this includes the response to the German V-1 program and the counter to German armor superiority. Unfortunately after the war NDRC/OSRD was disbanded and the United States fell back into a tradition of uncoordinated technology development…until Sputnik.

Case II: The Defense Advanced Research Projects Agency (DARPA)

After World War II the United States resumed its move towards commercial technology development. We were secured in the knowledge that the military had the atomic bomb and the delivery systems (B-29s) to ensure that our military maintained supremacy. Both of these technological advantages lasted only four years until the Soviets had equivalent systems of their own. But it would take the Soviet launch of Sputnik in October of 1957 to stir the United States into forming a new military technology development organization. On 7 February 1958, the Department of Defense issued DoD Directive 5105.15 to create "an agency for the direction and performance of certain advanced research and development projects."[18] On the civilian side Sputnik also helped to launch NASA. The intent of the organization was to prevent technological

surprise.[19] DARPA's organizational culture instills out-of-the-box thinking and tries to envision what is possible twenty years into the future.[20] Working with industry, DARPA has the independence to pursue technologies that the services may not be interested in. These projects are accessed based on their high risk and payoff. The agency has claimed many successes including the Unmanned Aerial Vehicles (UAVs), the M-16 rifle, the predecessor to the internet, and stealth technologies. However, along with these successes come projects that have been called: "Morally repugnant and unbelievably stupid."[21] DARPA leaders relish these criticisms as well believing they show that DARPA are on the cutting edge of technology.[22] The danger is that these failures will lead to more controls by Congress.

Transitioning DARPA technologies into fielded systems has also drawn criticism. DARPA does not develop fielded systems but leaves this up to the customer services. Instead DARPA focuses on taking the technical feasibility question "off the table".[23] Thus, DARPA's mission is a subset of NDRC/OSRD's and even though they have the ability to research any project, they do not necessarily have the capability to see it through to fielding. As a result, many of the systems DARPA claims credit for, have to be further developed by a service into a fielded system. Thus, when the United States faced the unexpected use of Improvised Explosive Devices (IEDs) DARPA was not in the position to lead the effort in response.

Case III: The Joint Improvised Explosive Device Defeat Organization (JIEDDO)

The U.S. experience in Iraq with IEDs is a case study of just how unprepared we were to respond quickly to an asymmetric technology threat. In Iraq, the enemy developed IEDs as his primary weapon system for inflicting casualties on U.S. and

Coalition forces. IEDs, as their name implies, can use any number of explosive and detonating devices to create the desired explosion and casualties. Insurgents learned to adapt their construction of IEDs to suit the situation.[24] It came as a surprise to many and the United States had no initial counter to this asymmetric threat. The use of IEDs is not a new technology or concept. In modern times they were regularly used by the now famous “Lawrence of Arabia” T.E. Lawrence against Turkish trains in World War I as recorded in his book *Seven Pillars:*

> In the next four months our experts from Akaba destroyed seventeen locomotives. Travelling became an uncertain terror for the enemy. At Damascus people scrambled for the back seats in trains, even paid extra for them. The engine-drivers struck. Civilian traffic nearly ceased; and we extended our threat to Aleppo by the mere posting of a notice one night on Damascus Town Hall, that good Arabs would henceforward travel by the Syrian railway at their own risk. The loss of the engines was sore upon the Turks. Since the rolling stock was pooled for Palestine and Hejaz, our destructions not merely made the mass evacuation of Medina impossible, but began to pinch the army about Jerusalem, just as the British threat grew formidable.[25]

The British experience in Northern Ireland is a more recent example of IEDs being used against a technologically superior foe. British responses mirror the United States’ response decades later.[26] Lacking an organization to take the lead in quickly recognizing and developing a response; IEDs weakened American resolve and jeopardized the strategic mission in Iraq.

March 29, 2003 was the first recorded use of IEDs against the U.S. Army in Iraq. It killed four U.S. Soldiers. IEDs rapidly came to represent the main threat to the U.S. military in Iraq causing 70% of U.S. causalities.[27] It took the United States six months to recognize IEDs as a strategic threat. Efforts to counter the threat began modestly with the formation of a small IED Task Force and Asymmetric Warfare Group (AWG) that focused on information sharing and TTP development. Stateside, the search for new

technologies to defeat the IED began. These efforts would eventually lead to the formation of the Joint Improvised Explosive Device Defeat Organization (JIEDDO) in February of 2006 – almost three years after the first use of an IED against US troops.

Formally created by DoD Directive 2000.19E, JIEDDO mission is to "focus (lead, advocate, and coordinate) all Department of Defense actions in support of the Combatant Commanders' and their respective Joint Task Forces' efforts to defeat Improvised Explosive Devices as weapons of strategic influence." Early on it was recognized that to defeat the insurgent's asymmetric use of IED technologies the US would have to rely on more than just new technology. The insurgents were adapting quicker than the US could equip its soldiers with IED defeat technologies. A combination of strategies would have to be used.

The directive formally tasked JIEDDO with defeating the IED, defeating the IED system (including interrupting the insurgent chain of IED activities) and training the force (mitigating the effects IEDs through training and information and strategic communications). To fulfill its mission, JIEDDO developed three lines of operation: 1. Attack the Network: which centered on, but was not limited to, collecting and providing intelligence to tactical units on the insurgent networks that are developing, building, and emplacing IEDs with the goal of eliminating the network. 2. Defeat the device: Combines activities that try to rapidly acquire new technologies that detect, destroy, or mitigate the IED and its effects. 3. Train the Force: JIEDDO provides training support to services and combatant commanders as they train personnel to recognize IEDs and protect against them.[28]

With over $14billion in funding already spent by JIEDDO, Congress has an interest in monitoring JIEDDO's operations and the progress the organization has made in countering the IED threat. While Congress is critical of how JIEDDO controls and tracks resources and measures success, they recognize JIEDDO has made contributions in reducing the IED threat and is thus part of the success of the Iraqi campaign.[29] Combatant Commanders and the Defense Department have recognized the contribution that JIEDDO has made to the fight against IEDs. The office of the Secretary of Defense is now looking at JIEDDO as the precursor to a larger and longer term effort to combat disruptive asymmetric technologies.[30] Thus the United States, after seven years of conflict, in an effort to close an unexpected technology gap is asking, "What else could surprise us and how do we prepare?" The government is now preparing to travel down the same path it trod during the Civil War, World War I, World War II, and the Cold War. It would be beneficial to compare some of the lessons learned from NDRC, DARPA and JIEDDO in responding to technology gaps and unexpected technologies developments. These three organizations provide a foundation from with much can be learned with regard to developing an organization to respond to unexpected technology breakthroughs.

Analysis: Comparing the NDRC/OSRD, DARPA and JIEDDO

When comparing past U.S. efforts responding to technology gaps and unexpected adversarial technology breakthroughs, a similar pattern of challenges emerges. These organizations all faced challenges in; resourcing (funding and personnel), integration with military services and their ongoing technology development

efforts, how they obtained and maintained visibility over national technologies, how oversight was maintained, and how acquisition processes were developed and used.

Funding: Several resourcing challenges exist in developing weapon systems. Many technologies take years to develop into a mature fielded system. Development is often subjected to changing funding pressures and priorities. When funding changes from year to year, not in accordance with the original funding plan, development slows and becomes more expensive. Thus most weapons development programs cite stable funding as a key to successful development. Organizations overseeing technology development also state that flexibility in funding is also critical to success. This funding flexibility allows the developing organization to redirect when unexpected problems occur.

During World War II, the NDRC recognized this as a key feature of their charter. NDRC was given flexibility, within reason, to transfer funds as needed to carry out research and experiments.[31] This is also a key attribute cited with JIEDDO.[32] JIEDDO funds currently last three years from the date of appropriation. This is a year longer than typical R&D funds. Additionally, Congress has provided the Secretary of Defense that ability to transfer funds between personnel, research and development, and procurement. JIEDDO officials cite this “colorless” money as “critical to develop and field new countermeasures rapidly”. [33] Stability with flexibility is critical from a programmatic stand point, but there is apprehension in Congress over such a freedom. Congress traditionally pushes for more visibility on how funds are spent. Currently JIEDDO is working to develop more robust systems to track its funding and

expenditures and even during World War II the NDRC realized that it had a responsibility to act fiscally with the funding it appropriated.

Personnel. The professions of scientist and engineer have long been honored careers within the United States. Many of these engineers and scientists work within the commercial sector generating new commercial products and services that fuel American industry and expansion. In times of war or national conflict it takes significant effort and motivation to reorient enough of these bright minds to respond to military needs for new and improved equipment. U.S. history has examples of what happens when the shift is too slow. During World War I much of the “high tech” equipment used by American soldiers was developed and made by our allies. It was only at the end of the war that U.S. industry momentum was beginning to change towards one capable of producing weapons like tanks, aircraft, and artillery. One of the key challenges was how to bring the high tech engineers over from the commercial industry to a place where they could contribute to military technology development. This challenge continues today. Often there are niche weapon technologies that are followed by only a handful of technical experts available to solve or respond to a gap or unexpected technology breakthrough.[34] Expanding to meet the technology gap prior to World War II, NRDC started in the spring of 1940 to attract the elite of academia and industry. President Roosevelt quickly established that scientist and engineers working on the committee should work for free. Surprisingly, rather than a hindrance in finding talented engineers and scientists, the committee actually felt this restriction worked in their favor as could they bring on qualified engineers and scientist “pro bono.”[35] Engineers and Scientists on the committee would stay in the employment of their companies and universities, but

work about one to two days per week solving America's technology gap. Since leaders from the key academic and corporate organizations had already signed on to lead the committee pro bono, the rest of industry fell in line. Industry and academia were no longer competing with government for vital technological expertise.

DARPA has taken a somewhat different approach. Since they look long-term into the future to see what technology can provide for the military, their need is not as urgent as NRDC or JIEDDO. They bring in talented engineers and scientists with innovative ideas are encouraged to join DARPA to work out their ideas.[36] They are usually on board for three or four years with a specific project goal in mind. Once completed, they return to industry or academia. In an effort to generate interest in defense among young scientists, DARPA has undertaken and effort "aimed at identifying and engaging junior faculty in academia and exposing them to Department of Defense needs and DARPA's program development process."[37] "DARPA's long-term goal for this program is to develop the next generation of academic scientists, engineers, and mathematicians in key disciplines who will focus a significant portion of their career on Department of Defense and National Security issues."[38] This is an example of meeting a critical need within U.S. industry generating interest in national defense among young and upcoming scientist and engineers to provide the United States the depth it needs in closing unexpected technology gaps.

Within JIEDDO, the need was more urgent. In order to rapidly expand and meet the needs of forces in Iraq and Afghanistan, JIEDDO had to rely upon contractors to quickly flesh out the required work force. The problem was that JIEDDO did this before it had a robust process to track contractors and expenditures and this has led to

Congressional scrutiny on how well JIEDDO is set up to monitor its personnel resources. Additionally, much of JIEDDO's funding comes from "supplementals" for Iraq. This supplemental funding is flexible allowing JIEDDO to spend on projects or personnel as needed, but it lasts for only a year which gives JIEDDO a temporary air to prospective employees making it harder to bring on long-term government employees.[39] As noted earlier, it is this flexible funding that provides JIEDDO the ability to respond quickly to the ever changing threat.

Coordination and Integration. Both the NDRC and JIEDDO have made a point of trying not to interfere with service research and development efforts in their area of interest. NDRC recognized that their mission was to supplement the services work.[40] However a critical factor in their success was to ability to "force" a project onto the service even when the service was opposed to the project. In the case of the DUKW, the floating 2 ½ ton truck that several historians have cited as crucial to helping the Allies to win World War II, the project was developed and fielded over the resistance from the Army until during a storm "On Cape Cod, an Army truck rescued the men from a stranded Navy vessel."[41] At this point, Army resistance faded away and the OSRD developed DUKW went to war.

Similar integration and coordination techniques have been used with the creation of liaison offices and teams by both NDRC and JIEDDO's operations. NDRC liaison activities were established with the United Kingdom and the U.S. military departments after the fall of France and before the US had officially entered the war.[42] Sharing scientific information also included commercial technologies (with that company's permission).

Figure 1. The DUKW at War

NDRC recognized from the start that achieving their mission of supporting the military service would require close liaison with the services. Scientist and military officers would work at bettering this relationship throughout the war. Eventually liaison officers were selected from the military that had both the military and technical backgrounds sufficient to understand the ongoing projects that he was assigned to.[43] One of the focus areas for these officers was the transmission of operational data back to the scientists in NDRC/OSRD. This was information was critical for scientists and engineers as it facilitated requirements assessments as well as providing information on new weapons system performance.

JIEDDO also incorporates liaison teams called “JIEDDO Field Teams” these military and civilian teams operate in theatre to act as:

> conduits back to JIEDDO for evolving C-IED requirements, and they report new IED tactics, techniques, and lessons learned in theater back to the training centers and JIEDDO’s headquarters. The teams also implement and manage JIEDDO’s C-IED initiatives in Iraq and Afghanistan.[44]

DARPA maintains contact with the services, but has similar challenges as NDRC as they are not obligated to meet service specific requirements for new equipment. Instead DARPA focuses on taking the "technology question off the table" by demonstrating a technology is doable but leaving the "heavy lifting of development and fielding" to the service."[45]

Knowledge Base. With a U.S. technology base that is so vast it is often hard to track who is working on what technologies. Since this is true of both the military and industry it makes it hard to respond to a technology gap or unexpected technology breakthrough without lot of inefficiencies and duplication of effort.

The development of the M1 Abrams main battle tank provides an example of the danger of these knowledge gaps. In 1972, after a failed attempt to develop a main battle tank to replace the M60, the task force responsible for developing what would become the M1 tank was trying to put a concept together that would defeat best of Soviet tank designs. Armor protection was critical to the concept, but only current common armor technologies the developmental task force had seen warranted inclusion on the concept. Then purely by chance, on a trip to the United Kingdom to review gun technologies the task force leaders were introduced to Chobham armor.[46] Nothing penetrated the armor. This was the breakthrough in armor protection that the task force was looking for. They were astonished to learn that US military research labs had similar technology and that they had been introduced to the technology back in 1964.[47] It would mean major changes to the task force's concept and they would have to convince an Armor community that did not want a tank that was over 47 tons. But today, the 72-ton M1 Abrams has become the best main battle tank in the world due in large

part to its armor protection. Technology stove piping and a lack of a technology knowledge base, combined with a “not invented here syndrome” almost caused the United States to miss an opportunity to revolutionize tank technology.

This lack of knowledge of who’s doing what research is commonplace and in 1940 NDRC worked hard to overcome it. The original committee members not only knew each other, they knew each other’s work. Additionally, they had an excellent knowledge of industry.[48] These allowed the committee to canvas U.S. industry and academia and rapidly develop a listing of which companies were working on what technologies. The Army and Navy representatives worked to collect all of the service development projects. These lists allowed the NDRC to track U.S. technology developmental progress and assist the services with timely and accurate input to existing developmental efforts.

Today, this is a critical short-coming within DoD. Services continue to run duplicate technology projects, and industry partners charged with bringing the best of industry into military projects fail on a regular basis to canvas what is truly available before completing a design. The GAO has been critical of JIEDDO for failing to understand, monitor, and coordinate counter IED efforts. GAO has called the JIEDDO efforts as “not consolidated, centralized, or coordinated.”[49]

Finally, many technology demonstration efforts show impressive technology results, but struggle because they are poorly transitioned into a developmental program. This has been a criticism of DARPA and other service Research and Development programs. This is due partly because the technology funding during the transition from the R&D effort into a formal developmental program for fielding is not well coordinated.

Recommendations

OSD is looking at expanding JIEDDO's mission of Countering IEDs to cover all asymmetric threats.[50] This effort acknowledges the successful approaches that JIEDDO has championed to reduce the IED threat by combining, technology development, intelligence collection, training and changing TTPs. However, this interest also creates a concern that JIEDDO's effectiveness may become diluted as it takes on more missions.[51] Clearly the United States is not currently prepared to respond quickly to unexpected adversarial technology breakthroughs nor is technology development as effective or efficient as it should be. Bolder moves are warranted to ensure that we are prepared in the future to respond to an unexpected technology breakthrough. The following six recommendations are an attempt to close this gap. They include:

- Create a Joint Functional Command for Technology Development
- Ensure Both a Requirements Pull and a Technology Push
- Ensure Stable Flexible Funding
- Improve Rapid Acquisition Processes
- Use Multiple Methods to Reduce the Impacts of Technology Gaps
- Reform the Acquisition Personnel Process

*Create a Joint Functional Command for Technology Development***.** Technology is arguably the most important contributor to military power. Maintaining a technological edge and avoiding technological surprises (such as the use of IEDs) before and during war is an important component of military power. Yet today there is no single command responsible for overseeing U.S. military technology development. Creating a four star level unified command responsible for the coordination and execution of all military

research and development would help to provide the unified leadership, visibility, and oversight needed within DoD. This will streamline weapons development from basic research activities to fielding activities. Combining DoD organizations like JIEDDO, DARPA and the Defense Science Board with service program offices under one command will help to streamline operations. This functional command for technology development would have broad powers to direct the services' research and development communities to provide systems in the most rapid and efficient manner eliminating duplication of effort. Additionally, it would have the responsibility of working with U.S. and Allies to establish and prepare for unexpected technology breakthroughs expanding the techniques JIEDDO has championed.

Ensure Both a Requirements Pull and a Technology Push. The new Technology Development Command (TDCOM) would work closely with Joint Forces Command (JFCOM) and service capability managers which have the responsibility for defining future operational concepts and describing what capabilities are needed in the future. This will ensure technology meets the warfighter's requirements for new capabilities (requirements pull). But like NDRC and DARPA, the proposed TDCOM would continue to have the authority to work with industry to investigate and develop radical high payoff high risk technologies that would be ensure the U.S. military maintains its technological advantage beyond what the warfighter is capable of envisioning (technology push). As seen in World War II, it was the technologies that were not understood by the warfighter and were resisted by the services that were often game changers leading to victory at the tactical, operational, and strategic levels. TDCOM would provide the needed

balance and oversight of projects to ensure that the technology developments are well grounded in science and not fantasy as this is often the criticism leveled at DARPA.

Like NDRC, TDCOM would maintain an extensive database of technology development going on in the United States and the world. Industry participation in providing data would be critical to ensuring it was up to date. As programs offices developed their systems they would be required to review this database prior to awarding a contract for weapons development. TDCOM inherited organizations like the Defense Science Board or its service equivalents would conduct a review of high priority development programs and their technical approach or design at critical milestones and design reviews throughout a programs development to ensure that the most current technology is being used.

Ensure Stable Flexible Funding. For at least sixty years the United States government has known that providing stable flexible funding is a key feature to insuring a successful weapon system development. Yet as seen in most budgetary laws passed by Congress, the trend is to place more restraints on a programs funding. All would accept that Congressional oversight is required to ensure abuses are reduced. One recommendation would be to provide the reprogramming authority down to the TDCOM commander and provide him a limited set of funds that allows him to respond to emerging technology challenges. A formal process should be developed and suggested to Congress to ensure Congressional visibility and oversight is maintained.

Improve Rapid Acquisition Processes. Currently there are at least five processes to rapidly acquire equipment within DoD and the military services. These processes and the organizations that run them (like JIEDDO and the Army's Rapid Equipping Force)

meet emerging needs from war fighters in Iraq and Afghanistan. They rapidly access the requirements and try to find an item that will meet the need. They focus equipping the unit in theater rather than accomplishing the more formal and time-consuming fielding process. They can often meet the need in days, but the averages are bearing out that it takes between six months to a year or more to place equipment in the hands of the solders in the field.[52] Often this equipment is the type that is available “off the shelf” with limited development to no development needed or from another military source. DoD’s Joint Rapid Acquisition Cell is currently completing a study that will try to identify lessons and best practices for these processes. What is needed is a formal uniform rapid acquisition process across the services that take the best ideas of the five processes and incorporates it into a single standard process.

Use Multiple Methods to Reduce the Impacts of Technology Gaps. As seen with the JIEDDO experience, combining multiple approaches often works the best in responding to an unexpected use or breakthrough of technology. When the Allies were confronted with the Nazi’s V-1 “buzz bomb”, NDRC combined its VT fuze with radar and a new fire control system to greatly reduce the number of V-1s that got through while the Air Forces learned new TTPs on how to attack flying V-1s and ultimately found and destroyed the V-1 launch sites. In the future, multiple approaches will continue to be the key to successfully responding to technology threats. With the current minimum of six months to a year to get off- the-shelf technology into the hands of the Soldier, it must be acknowledged that the first response to an unexpected technology breakthrough will be in the area of a change in friendly TTPs. What must be avoided is an uncoordinated

response. The TDCOM must coordinate closely with the intelligence community and in tandem with JFCOM and service doctrine commands to develop the new TTPs.

Acquisition Personnel Reform. NDRC found that the most successful military officers working within the technology development field had a combined background of science and engineering. The technical background combined with their military service equipped them to effectively contribute while serving with NDRC. Today many acquisition officers are placed into technology development programs where they have neither the educational background nor the military experience needed to oversee the project.[53] Additionally, with the loss of service R&D civilians due to retirement and the effects of the base realignment and closure service officials have moved to outsource most of the technical skills within research, development and acquisition. This has reached its zenith with the concept of Lead System Integrators. Lead System Integrators (LSIs) are in essence general contractors with broad authority to manage large programs. Working everything from requirements determination to production preparation, they have been called the proverbial “fox guarding the hen house.” They have drawn criticism from Congress and thus the LSI concept faces an uncertain future. Services using the LSI concept have effectively transferred their technical knowledge bases to industry (often at a premium price to the government) and have not developed their research and development workforce to the levels needed to ensure effective oversight of programs. Military services should reverse this trend and insist that a significantly larger portion of its research, development, and acquisition workforce have or obtain higher degrees in engineering and hard sciences. Ultimately the military needs

to regrow and retain its ability to perform technical oversight of complex developmental programs.

Conclusion

When a technological breakthrough is achieved it usually takes the adversary about four to five years to develop a similar technology or a response and erase the advantage. The counter IED effort in Iraq has followed this trend as well. In this case we were fortunate, U.S. history contains examples of we developed an unexpected technology advantage used it on our adversary to achieve tactical victories (VT fuze and the battle of the Bulge), operational victories (U.S. code breaking and the Pacific Theater) and strategic victories (U.S. development of the heavy bomber and the victory over Japan). The United States maintains a technology edge because it is an efficient way to victory. However, we are in danger of losing this ability by being complacent and thus need to make major adjustments to the way we develop and maintain our military technological lead. Only this will minimize the probably and impacts of facing a strategic level unexpected technology breakthrough.

Endnotes

[1]Two examples of this is are *The Joint Improvised Explosive Device Defeat Organization: DOD's Fight Against IEDs Today and Tomorrow,* U.S. House of Representatives Committee on Armed Services Subcommittee on Oversight & Investigations, November 2008 and the *Office of the Secretary of Defense Joint Rapid Acquisition Cell Lean Six Sigma Study on Rapid Acquisition Processes*. These studies are just two of many that get at looking at what works in terms of rapidly fielding or equipping U.S. forces to combat an asymmetric technology edge.

[2] Norman Polar, "Good News-Bad News on UAVs (Depending on Who You Are)," *Defense Tech,* October 4, 2007, http://www.defensetech.org/archives/003765.html (accessed 24 January 2009). This article contains examples of these inefficiencies is seen in the development of UAV's within the U.S. military. Currently no service or organization has the lead role in developing UAVs. Over 100 UAVs are now in production or development.

[3]In 2007 the total number of U.S. patents was 2,004,080 compared to the total for the rest of the world: 1,634,736. Source: *U.S. Patent and Trademark Office,* http://www.uspto.gov/go/taf/cst_all.htm (accessed 21 January 2009)

[4]Max Boot, *War Made New; Technology, Warfare, and the Course of History 1500 to Today* (New York: Gotham Books, 2006), 264.

[5]Irvin Stewart, *Organizing Scientific Research for War* (Boston: Atlantic Monthly Press, 1948), 4.

[6]Ibid., 6.

[7]Ibid.

[8]Ibid., 8.

[9]Ibid., 26.

[10]Ibid., 18.

[11]Ibid.

[12]Ibid., 322.

[13]Ibid., 34

[14]Ibid.

[15]Ibid., 36.

[16]American Chemical Society National Historic Chemical Landmarks, "United States Synthetic Rubber Program, 1939-1945," http://acswebcontent.acs.org/landmarks/landmarks/rbb/ (accessed January 13, 2009).

[17]Geoffrey Perret, *There's a War to Be Won; The United States Army in World War II,* (New York: Ivy Books, 1991), 88 – 90.

[18]U.S. Department of Defense, *U.S. Department of Defense Advanced Research Projects Agency, DoD Directive 5105.15*, February 7, 1958, http://www.darpa.mil/Docs/DARPA_ Original_Directive_1958_ 200807180942212.pdf (accessed January 6, 2009).

[19]Graham Warwick and Guy Norris, "DARPA at 50, Blue Sky Thinking," *Aviation Week and Space Technology,* August 18/25 2008, http://www.darpa.mil/Docs/125013846_Eprint_ 200811141152151.pdf (accessed January 6, 2009).

[20]Ibid.

[21]Charles Piller, "Army of Extreme Thinkers; The Brilliant Successes of DARPA, the Defense Department's Advanced Research Agency, Are Matched Only by Its Long List of Bizarre Failures," *Los Angeles Times*, August 14, 2003, in ProQuest (accessed January 21, 2009).

[22]Ibid.

[23]Warwick, “DARPA at 50, Blue Sky Thinking,” 4.

[24]Rick Atkinson, “Left of Boom, The Struggle to Defeat Roadside Bombs,” *Washington Post Online*, http://www.washingtonpost.com/wpdyn/content/story/2007/09/29/ST2007092900754.html?sid =ST2007092900754 (accessed November 10, 2008).

[25]T.E. Lawrence, *Seven Pillars of Wisdom*, Book 5, Chapter 67, Project Gutenberg of Australia eBooks, October 2001, http://www.wesjones.com/seven%20pillars/sevenpillars%2005.xml, (accessed November 14, 2008)

[26]The British began to use fortified outposts to resist IRA bombers movement and began to arrest the IRA leadership responsible for the bombings. They cleared and held the neighborhoods and took down the bombers networks.

[27]Rick Atkinson, “Left of Boom, The Struggle to Defeat Roadside Bombs.”

[28]U.S. Congress, House of Representatives, Committee on Armed Services, Subcommittee on Oversight and Investigations, *The Joint Improvised Explosive Device Defeat Organization: DOD’s Fight Against IEDs Today and Tomorrow* (Washington D.C: House Armed Services Committee, November 2008), 15. http://armedservices.house.gov/pdfs/Reports/JIEDDOReportNov2008.pdf, (accessed January 24, 2009).

[29]Ibid., 9.

[30]Ibid., 45.

[31]Stewart, *Organizing Scientific Research for War,* 8.

[32]U.S. Congress, House of Representatives, Committee on Armed Services, Subcommittee on Oversight and Investigations, *The Joint Improvised Explosive Device Defeat Organization: DOD’s Fight Against IEDs Today and Tomorrow,* 30.

[33]Ibid.

[34]This is the author’s experience. In most of the acquisition positions there are usually only a handful of experts available to solve a technical problem. Most are already in the employment of the government making responding to new threat technologies challenging.

[35]Stewart, *Organizing Scientific Research for War,* 26.

[36]Warwick, “DARPA at 50, Blue Sky Thinking,” 4.

[37]U.S .Fed News, “DARPA Engages Next-Generation Academics,” January 15, 2009, in ProQuest, (accessed January 21, 2009).

[38]Ibid.

[39]U.S. Congress, House of Representatives, Committee on Armed Services, Subcommittee on Oversight and Investigations, *The Joint Improvised Explosive Device Defeat Organization: DOD’s Fight Against IEDs Today and Tomorrow,* 30.

[40]Stewart, *Organizing Scientific Research for War*, 8.

[41]Perret, *There's a War to Be Won; The United States Army in World War II*, 112.

[42]Stewart, *Organizing Scientific Research for War*, 168.

[43]Ibid., 154.

[44]U.S. Congress, House of Representatives, Committee on Armed Services, Subcommittee on Oversight and Investigations, *The Joint Improvised Explosive Device Defeat Organization: DOD's Fight Against IEDs Today and Tomorrow,* 22.

[45]Warwick, "DARPA at 50, Blue Sky Thinking," 4.

[46]Orr Kelly, *King of the Killing Fields; The Story of the M-1 America's Super Tank* (New York: W.W. Norton, 1989), 112.

[47]Ibid., 120.

[48]Stewart, *Organizing Scientific Research for War*, 22.

[49]U.S. Congress, House of Representatives, Committee on Armed Services, Subcommittee on Oversight and Investigations, *The Joint Improvised Explosive Device Defeat Organization: DOD's Fight Against IEDs Today and Tomorrow,* 23.

[50]Ibid., 45.

[51]Ibid., 24.

[52]Department of Defense, Joint Rapid Acquisition Cell, *Lean Six Sigma Project Briefing Rapid Acquisition Cross Functional Team Executive Summary Draft Presentation*. January 2009, provided to the author by JRAC Cell.

[53]This is the author's personal observation. Currently only 18% of the Army Acquisition Corps has higher degrees in hard sciences and engineering. Additionally, in an effort to broaden career experiences, officers are placer where they have no military or educational background.